101-03481 Hydro-Québec : a strategy for the 80's

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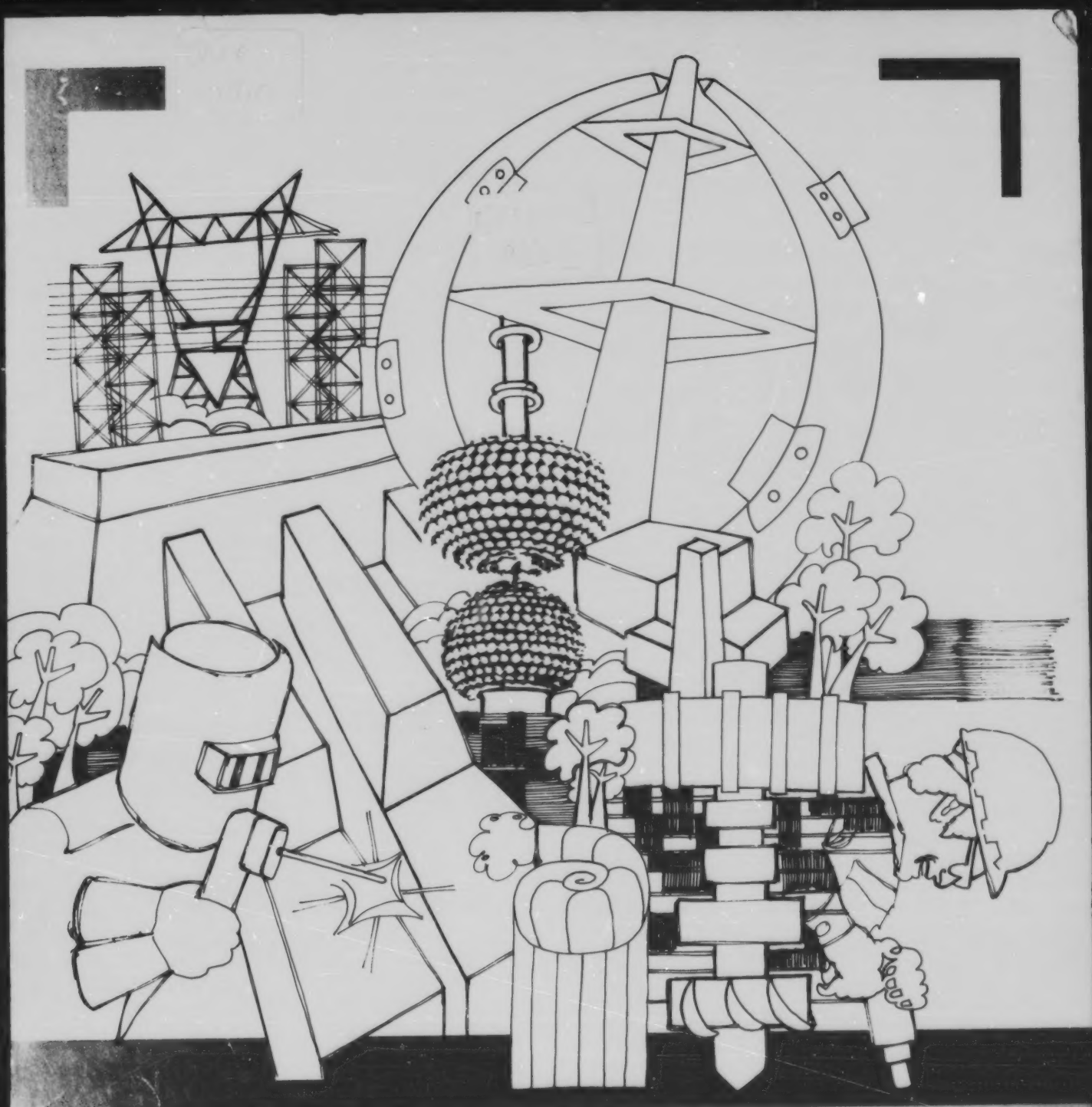

A strategy for the 80's

A strategy for the 80's

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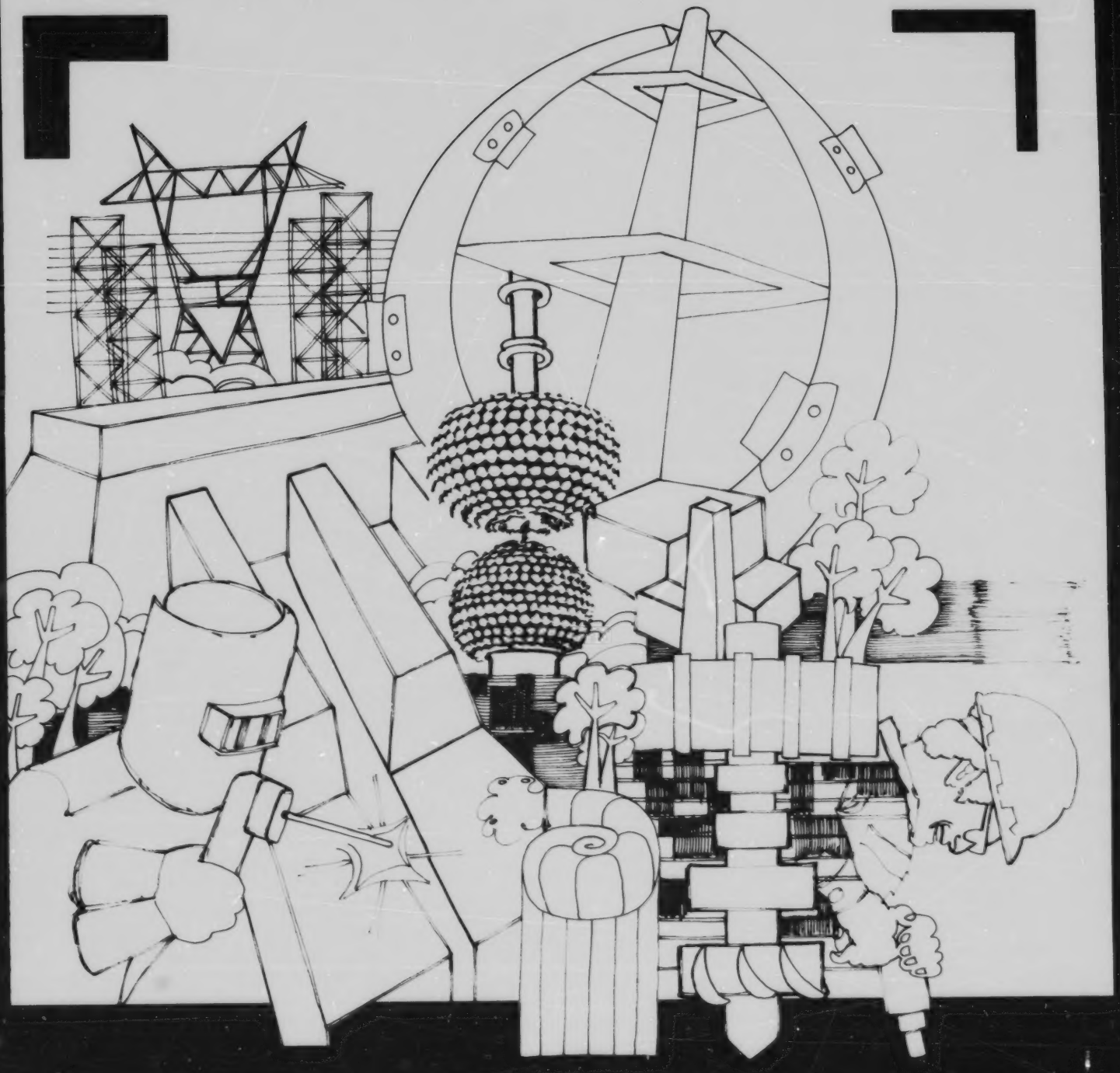

THE MANDATE OF HYDRO-QUÉBEC

"The object of the Corporation shall be to supply power to the municipalities, industrial or commercial undertakings and citizens of this Province at the lowest rates consistent with sound financial administration ..."

"To attain its objects, the Corporation shall estimate the needs of Québec in energy and the means of meeting them within the scope of the energy policies that the Lieutenant-Governor in Council may otherwise establish." (sections 22 and 22a of the Hydro-Québec Act)

FOREWORD

Since the appearance of the first signs of what is called "the energy crisis," every industrialized country has tried to protect itself against the large and repeated increases in the costs of fossil fuels and the risks of seeing these resources exhausted.

Since Québec has no oil reserves and can count on only limited supplies of Canadian natural gas, its energy future must be directed along paths which are open to it. In addition to putting emphasis on energy conservation measures, even though their effects may be slow in being felt, Québec can rely for at least some time to come on developing the hydroelectric resources with which it is endowed.

In such a context, Hydro-Québec's mandate takes on prime importance, and the decisions made by the utility will have a decisive impact not only on Québec's energy future but also on its future economic and social development.

While Hydro-Québec will discuss its future investment plans before the members of the Parliamentary Committee on Energy and Resources next February, it would also like to inform the public of its plans, so that the people of Québec can participate in a joint review of the utility's orientation for the next decade and of the projects considered necessary to carry out its mandate, in the best interests of the citizens of Québec.

In a period marked by uncertainty, systematic and continuous planning are more necessary than ever before, but the planning process is also more difficult than ever. Thus, while establishing the future power requirements of Québecers as realistically as possible, Hydro-Québec must also define how these requirements will be satisfied, while taking increasingly complex factors into account. These factors include major social trends, concern for environmental quality, economic and energy prospects and, of course, the availability of the human, material and financial resources needed to implement the strategy adopted. Many factors mean many sources of uncertainty.

That is why a plan must be regarded not as a strait and narrow path to the future but as an itinerary, flexible enough for favorable opportunities to be exploited and unexpected obstacles avoided.

That is why a plan can never be considered finished. It must be constantly improved with new data. Hydro-Québec hopes that the impending dialogue on its future will contribute just those elements that will allow its strategy for the 80's to be perfected.

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INTRODUCTION

To fulfill its mandate, Hydro-Québec must be sure that it always has sufficient sources of electricity to meet a growing demand whose characteristics are constantly changing. This necessity requires long-term planning of both equipment and investments.

In fact, several years pass between the decision to build a power station and the moment it generates its first kilowatthours. This means that Hydro-Québec must constantly be preparing for the future. Decisions which will ensure the availability of electrical power in ten or even fifteen years' time must be made or prepared today. The planning of Hydro-Québec installations is thus a vital and continuous corporate activity.

A strategy for the 80's presents the optimal combination of installations allowing Hydro-Québec to satisfy Québec's power requirements in the years to come, in terms of the quantitative and qualitative development of demand.

It has been devised taking into consideration highly diverse factors which are vital to ensure its effectiveness and suitability for the social and economic context of Québec. It is the culmination of complex studies following a well-marked path.

Forecasting the demand for electricity is the starting point of the planning process, allowing the electricity requirements of the people of Québec to be defined. The latest results of this exercise and the main features of the forecasting process are described in Chapter 1 of this report.

Chapter 2 contains the actual Installations Plan. It sets out the selection of required facilities, the order in which they will be commissioned, and the human and financial resources needed to implement the plan.

Chapter 3 gives an overview of the options available to Hydro-Québec to fulfill its mandate during the last decade of the century and beyond.

CHAPTER 1

FORECAST OF ELECTRICITY DEMAND

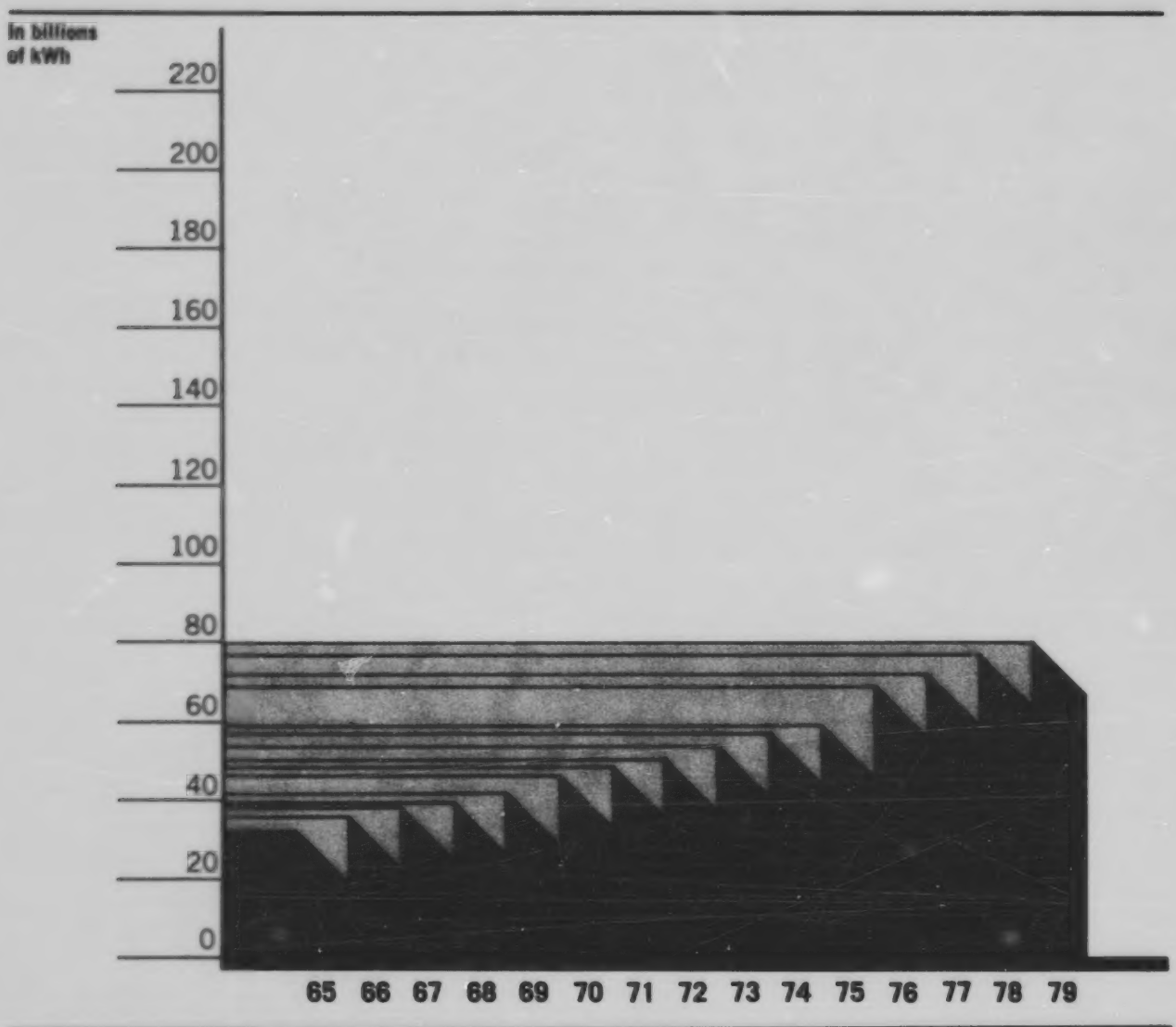
FROM 1980 TO 1996

A) A LOOK BACK

Figure 1.1

Firm electricity sales in Québec 1965 to 1979

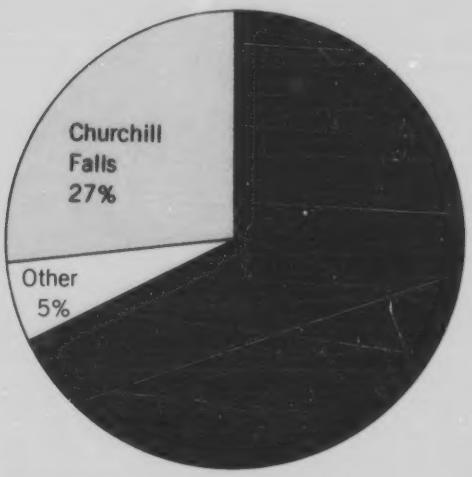
In the last fifteen years, firm electricity sales in Québec have more than doubled. In 1979, sales were 79.1 billion kilowatthours, compared with 31.8 billion in 1965, for an annual average increase of 6.7%.



Most of this electricity comes from Hydro-Québec generating stations and also from other systems.

Figure 1.2

Electricity source*



*During 1979-1980 winter peak

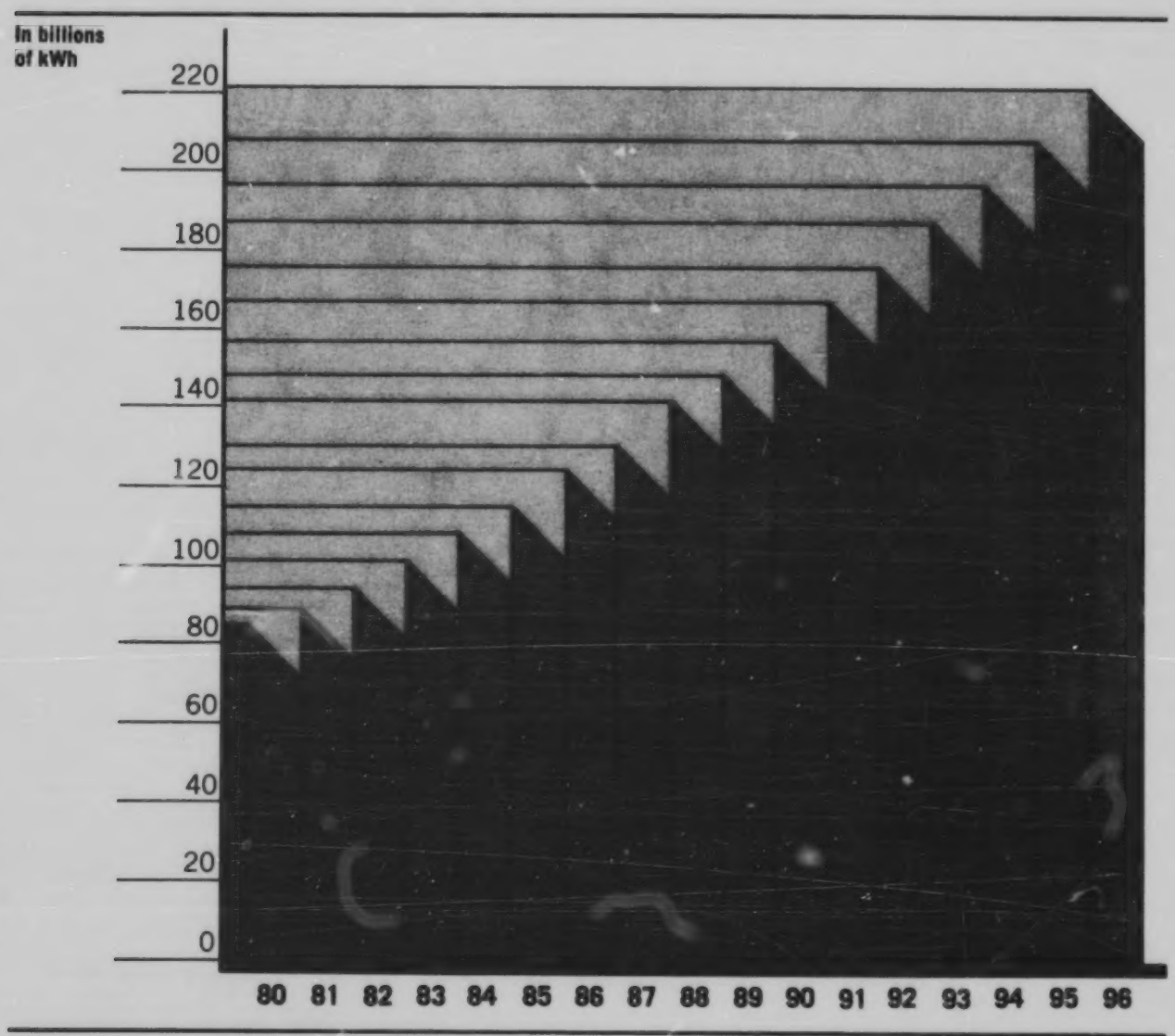
At present, more than 99% of the electrical energy sold by Hydro-Québec is generated hydroelectrically.

B) THE SELECTED FORECAST

Figure 1.3

Forecast firm electricity sales in Québec 1980 to 1996

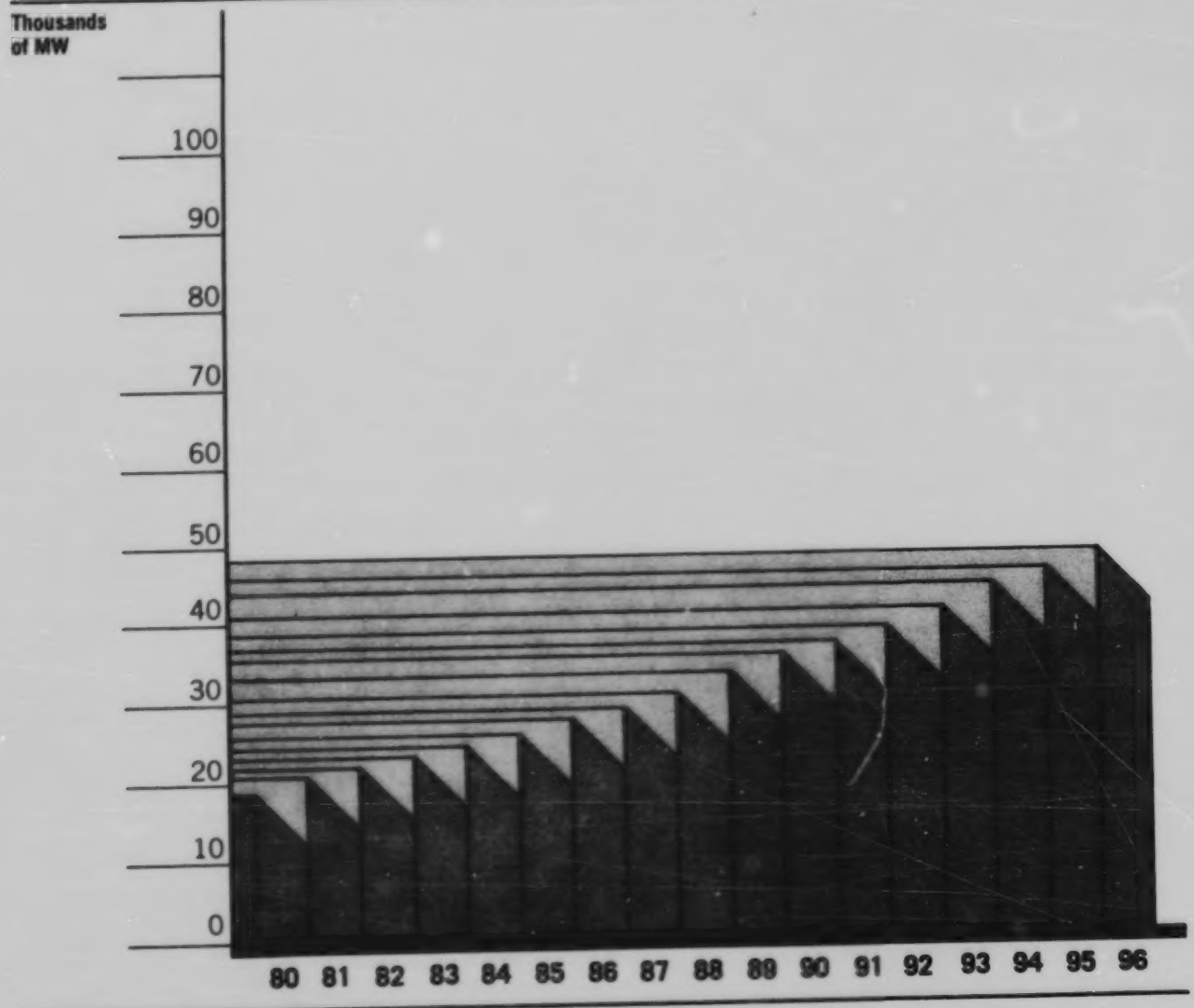
Hydro-Québec estimates that its sales of firm electricity in Québec will grow at an average annual rate of 6.2% between 1980 and 1996. In 1996, such sales will be about 222 billion kilowatthours, compared with 79 billion in 1979.



In this same period, Québec's firm power requirements will grow 6.0% per year, rising from 18,950 megawatts to 47,900 megawatts, while firm energy requirements will amount to 250 billion kilowatthours.

Figure 1.4

Forecast priority power requirements* 1980 to 1996



* Winter peak starting in December of year indicated

Table 1.1 indicates anticipated annual growth in sales and priority requirements until 1996.

TABLE 1.1

ANTICIPATED GROWTH OF FIRM ELECTRICITY SALES IN QUÉBEC AND PRIORITY REQUIREMENTS FROM 1980 TO 1996

	Firm electricity sales in Québec		Priority requirements			
			Energy		Power *	
	billions of kWh	%	billions of kWh	%	MW	%
1980	84.7	7.0	98.2	7.4	18,950	7.7
1981	89.6	5.8	103.6	5.5	20,200	6.6
1982	95.4	6.5	110.1	6.3	21,500	6.4
1983	102.2	7.1	117.7	6.9	23,000	7.0
1984	109.4	7.1	125.6	6.7	24,600	7.0
1985	116.8	6.8	134.0	6.7	26,300	6.9
1980-85		6.6		6.4		6.8
1986	124.5	6.6	142.5	6.3	28,000	6.5
1987	132.5	6.4	151.5	6.3	29,800	6.4
1988	140.6	6.1	160.5	5.9	31,600	6.0
1989	149.1	6.1	170.0	5.9	33,400	5.7
1990	158.1	6.0	180.0	5.9	35,200	5.4
1986-90		6.2		6.0		6.0
1991	167.3	5.8	190.1	5.6	37,000	5.1
1992	177.1	5.8	200.8	5.6	39,000	5.4
1993	187.3	5.8	212.0	5.6	41,100	5.4
1994	198.2	5.8	223.9	5.6	43,300	5.4
1995	209.7	5.8	236.5	5.6	45,600	5.3
1996	221.9	5.8	249.8	5.6	47,900	5.0
1991-96		5.8		5.6		5.2
1980-96		6.2		6.0		6.0

* Peak for the winter starting in December of the year indicated.

This forecast is the basis for planning and selecting the installations Hydro-Québec must build to meet future electricity requirements. It is the result of a multidisciplinary process, involving estimates made by specialists from major departments of Hydro-Québec. Drawn up for a fifteen-year period, the forecast is revised annually to allow prompt adjustment to changes.

Three Major Factors

Future demand for electricity is closely linked to developments in the following areas:

- demographic growth
- economic growth
- the energy situation.

C) HYPOTHESES OF DEMOGRAPHIC TRENDS

The forecast of demographic growth used in the planning process indicates that the population of Québec will increase from 6,283,000 in 1978 to 7,007,000 in 1996, which amounts to an average annual increase of 0.6% (see Table 1.2). This forecast suggests a slowdown compared with past trends (1.1% from 1961 to 1976) and corresponds to the most likely scenario proposed by the Bureau de la statistique du Québec (B.S.Q.)[1]. This scenario is based on the results of the 1976 census and reflects the negative net migration of 1977, 1978 and 1979.

The number of households will increase by an average of 1.7% per year until 1996, compared with 3% from 1960 to 1978.

B.S.Q. forecasts also indicate that during the next fifteen years, the portion of the population under fifteen years of age will decrease, while the proportion of those sixty-five and older will increase. This trend toward an aging population, noted in all industrialized countries, is thus also appearing in Québec. In the medium term, this phenomenon tends to increase the size of the work force, and as a result, the demand for energy related to the production of goods and services. However, in the longer term, the reverse effect can be anticipated.

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(1) Bureau de la statistique du Québec, Perspectives démographiques pour le Québec et ses régions administratives - Trois hypothèses 1976-2001, Québec, Éditeur officiel du Québec, 1980.

Table 1.2 shows growth in the total population and in the number of households in Québec from 1978 to 1996.

TABLE 1.2

THE POPULATION AND THE NUMBER OF HOUSEHOLDS IN QUÉBEC FROM 1978 TO 1996

	1978	1980	1985	1990	1996
Population (in thousands)	6,283	6,359	6,602	6,832	7,007
Increase in % *		0.6	0.8	0.7	0.4
Households (in thousands)	1,944	2,067	2,330	2,501	2,627
Increase in % *		3.1	2.4	1.4	0.8
Number of persons per household	3.23	3.08	2.83	2.73	2.67

* Average annual increase during the immediately preceding period.

D) HYPOTHESES OF ECONOMIC TRENDS

The rate of growth of the Gross Domestic Product (GDP) is a function of the growth rates of employment and work force productivity.

- Growth in employment is directly linked to the demographic forecast used and to various hypotheses concerning the rate of participation of the work force. These hypotheses are based on the assumption that the participation rate for men will be maintained but the rate for women will increase significantly.

- The rates forecast for productivity are the result of a historical analysis of Québec and Canadian experience.

According to the hypotheses used, the GDP of Québec should increase at an average annual rate of 3.4% between 1980 and 1996, with the following periodic variations: 3.3% from 1980 to 1990 and 3.6% from 1990 to 1996. It is not expected that the relative proportions of the primary, secondary and tertiary sectors will undergo major changes during this period.

Table 1.3 shows the hypotheses used in the trends for particular economic indicators in Québec for the 1978-1996 period.

TABLE 1.3

TRENDS FOR PARTICULAR ECONOMIC INDICATORS IN QUÉBEC FROM 1978 TO 1996

	1978	1980	1985	1990	1996
Population 15 years and over (in thousands)	4,735	4,939	5,165	5,314	5,508
Participation rate (%)	59.7	60.2	62.5	65.1	68.9
Work force (in thousands)	2,827	2,974	3,230	3,462	3,795
Unemployment rate (%)	10.9	10.3	8.7	7.0	6.5
Number of jobs (in thousands)	2,519	2,668	2,951	3,218	3,548
Job growth (%) *	-	2.9	2.0	1.7	1.6
Productivity growth (%) *	-	-0.8	1.3	1.6	2.0
Growth of GDP (%) *	-	2.1	3.3	3.3	3.6

* Average annual increase during the immediately preceding period.

E) THE ENERGY SITUATION

Since 1970, there has been a marked slowdown in the growth of overall energy consumption. This slowdown can be explained by a difficult economic situation, the increase in energy conservation and a saturation of consumption in particular applications.

However, there has been no slowdown in the growth of the demand for electricity during this period. In fact, it has continued to grow at nearly the same rate as during the 60's. While this might appear surprising at first glance, closer examination reveals that the phenomenon of replacing oil by other energy sources, particularly electricity, has greatly increased electricity's share of Québec's total energy consumption. Consequently, demand for electricity has been maintained at high levels.

It is anticipated that this substitution phenomenon will continue and even intensify until 1996. Thus, electricity should account for 45% of energy consumption in 1996, compared with 26% in 1978. Natural gas is likely to experience the same phenomenon, increasing from 6 to 12% during the same period.

During this time, energy consumption will increase by only 2% per year overall, in view of anticipated energy conservation, which by 1996 should reduce by 17% the overall consumption of energy compared to what it would have been, had it continued to grow according to the trends noted before 1978.

The increase in electricity's share in Québec energy use will occur primarily in the residential sector and, to a lesser degree, in the commercial sector. This can readily be explained by the competitive position enjoyed by electricity compared with other forms of energy used in heating.

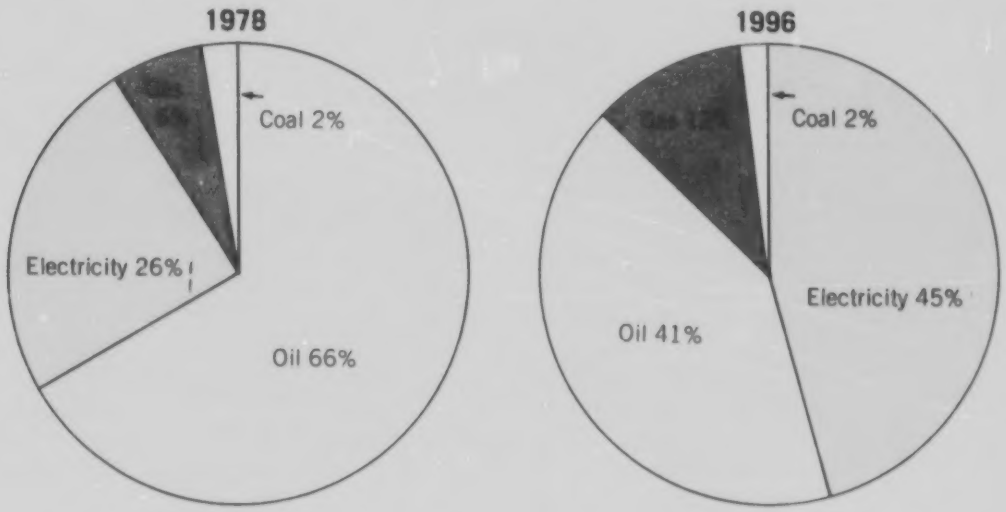
Gas will mainly penetrate the industrial sector, where it will partially replace heavy petroleum products. Gas may also make inroads in the home and commercial heating markets.

In summary, oil will lose the larger part of its present market in the residential and commercial sectors and will only continue to dominate the transportation and industrial sectors.

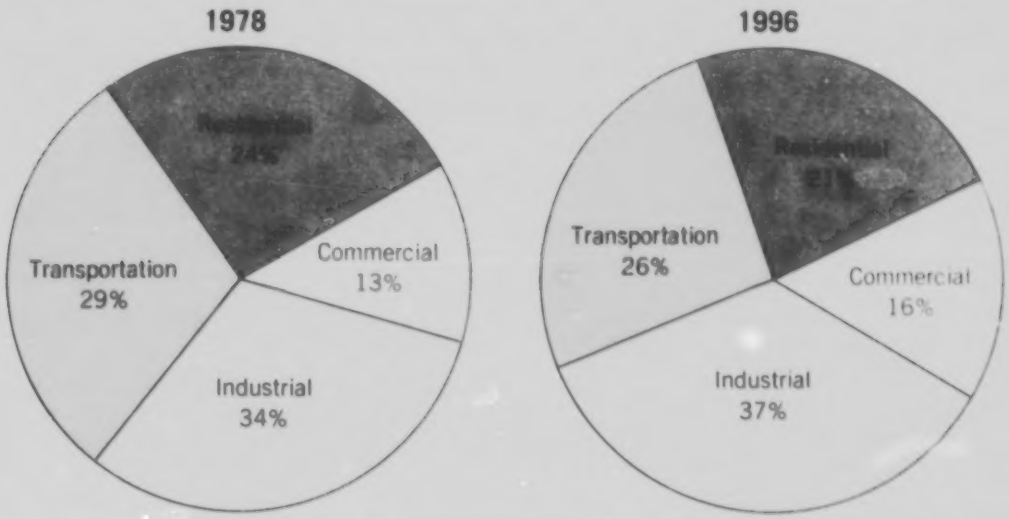
Figure 1.5

Québec's energy breakdown 1978 to 1996

Supply



Demand



F) FORECAST OF FIRM ELECTRICITY SALES BY HYDRO-QUÉBEC IN QUÉBEC BY CATEGORY OF USE

Table 1.4 shows the main trends in the sales of firm electricity by category of use.

TABLE 1.4

FORECAST OF FIRM ELECTRICITY SALES BY HYDRO-QUÉBEC IN QUÉBEC BY CATEGORY OF USE FROM 1980 TO 1996

(in billions of kWh)

Category of use	1980	1985	1990	1996	% of annual variation 1980-1996
Residential and farm	29.5	45.2	62.2	84.1	6.8
Industrial	32.1	40.0	51.9	70.6	5.0
General	19.0	26.0	36.0	54.0	6.7
Other uses	4.1	5.6	7.9	13.2	7.6
Total firm electricity sales *	84.7	116.8	158.1	221.9	6.2

* Figures are rounded off, so totals may be different from the sum of the categories.

1) Residential and Farm Uses

Firm electricity sales for residential and farm uses amounted to 27.5 billion kilowatthours in 1979, compared with 8.3 billion in 1966, which is an average annual increase of 9.6%. These sales represented about 35% of firm electricity sales by Hydro-Québec in Québec in 1979.

Table 1.5 shows forecast of firm electricity sales for residential and farm uses by application. It reflects possible electricity savings, discussed in the next section, as well as increased penetration by electricity in the heating market.

These sales will increase 7.8% per year between 1980 and 1990 and 5.1% between 1990 and 1996, for an average increase of 6.8% over the whole period.

TABLE 1.5

RESIDENTIAL AND FARM USES
SALES BY APPLICATION FROM 1980 TO 1996
REFLECTING ELECTRICITY SAVINGS

(in billions of kWh)

Types of Application	1980	1985	1990	1996	% of annual variation 1980-1996
					%
Heating	11.2	19.9	29.3	41.0	8.4
Other	18.3	25.3	33.0	43.1	5.5
Total *	29.5	45.2	62.2	84.1	6.8

* Figures are rounded off, so totals may be different from the sum of the applications.

2) Industrial Use

The consumption of electricity in industry is a function of production volume, efficiency of electricity consumption by equipment and manufacturing processes, and the rate at which electricity replaces other forms of energy.

The pulp-and-paper and metal-manufacturing industries exert the greatest influence on the growth of electricity consumption in Québec industry, because they account for more than half of such consumption.

Table 1.6 shows estimates of consumption by various industries in Québec.

TABLE 1.6

ELECTRICITY CONSUMPTION * FOR INDUSTRIAL USE FROM 1980 TO 1996

REFLECTING ELECTRICITY SAVINGS

(in billions of kWh)

	1980	1985	1990	1996	% of annual variation 1980-1996
Paper and allied industries	16.2	18.1	20.8	24.2	2.5
Primary metal industries	23.4	24.9	27.4	30.6	1.7
Non-metallic mineral products industries	1.3	1.6	1.9	2.8	4.6
Chemical and chemical products industries	3.5	4.0	5.0	6.1	3.6
Food & beverage industries	1.2	1.4	1.8	2.4	4.6
Textile industries	0.8	1.2	1.4	2.1	5.8
14 other sectors	4.7	6.2	7.8	11.3	5.7
Total: manufacturing industries **	51.0	57.4	66.2	79.5	2.8
Primary and construction industries	3.5	5.0	8.1	13.5	8.9
Total consumption for industrial use	54.5	62.4	74.3	93.0	3.4
Self-generated electricity	(22.4)	(22.4)	(22.4)	(22.4)	-
Firm electricity sales by Hydro-Québec	32.1	40.0	51.9	70.6	5.0

* Figures for each of the industries include requirements satisfied by producers other than Hydro-Québec.

** Figures are rounded off, so totals may be different from the sum of the industries.

3) General Use

The general use category includes mainly shopping centres, schools, hospitals, office buildings, government buildings, restaurants, hotels, motels, retail stores and recreational facilities.

Firm electricity sales for general use are expected to amount to 54 billion kilowatthours in 1996, for an average annual increase of 6.7%. This is a major slowdown compared to the trend observed until 1980, despite the widespread penetration of electricity in the heating of commercial buildings and the introduction of new equipment using electricity. The slower growth rate can be attributed to energy conservation and the anticipated slowdown in the growth of the service sector of the economy.

4) Other Uses

The "other uses" category consists of sales to municipal distribution systems, public lighting, public transportation, Hydro-Québec's own use at its construction sites, etc. Firm electricity sales for these uses should amount to 13.2 billion kilowatthours in 1996, an average annual increase of 7.6%.

G) CONSERVATION OF ELECTRICITY

Since 1973, many factors have contributed to increase the demand for electricity, particularly the increase in the price of petroleum and its replacement by other forms of energy. Since these factors are likely to continue to apply in the next fifteen years, the increase in the demand for electricity might be expected to continue to grow at the same rate as in the past.

However, electricity conservation due to various technological changes and government action will doubtless dampen this trend. That is why the forecast growth of electricity consumption is slightly lower than the historical trend.

Table 1.7 gives an overall view of electricity savings forecast for various uses as compared with 1978 consumption.

TABLE 1.7

FORECAST SAVINGS OF ELECTRICITY IN 1985 AND 1996

COMPARED TO THE TREND OBSERVED IN 1978

Category of use	1985 %	1996 %
Residential and farm	4	7
Industrial	7	11
General	12	17
TOTAL	7	11

Table 1.8 shows the sources of electricity savings.

TABLE 1.8

SOURCES OF ELECTRICITY SAVINGS IN 1996

	% of total
Residential heating	
- new buildings	3
- conversions	9
Household appliances	7
Various savings	3
Air conditioning - commercial sector	
- new buildings	22
- old buildings	5
Other uses, commercial sector	
- new buildings	15
- old buildings	6
Pulp and paper industry	7
Primary metals industries	17
Other industries	7
TOTAL	100 *

* Since the figures were rounded off, the sum of all the percentages does not equal 100%.

H) SENSITIVITY OF FORECAST

Even when made with care, forecasts of the demand for electricity cannot be completely accurate because they are subject to the impact of factors whose future course may be difficult to predict exactly. That is why Hydro-Québec also studies how changes in basic hypotheses might affect its forecast. Such a study was carried out on two basic factors in the forecast used: demographic trends and the energy situation.

- Demography: Hydro-Québec evaluated the effect on future electricity demand of both higher and lower population growth than that used in making the forecast.

- Energy: Hypotheses calling for faster penetration by natural gas and more rapid increases in the price of oil were studied and their likely effect on the demand for electricity was measured.

The utility also estimated the impact of a rapid penetration by gas coupled with low demographic growth, and the effect of an oil crisis coupled with high demographic growth.

The results of this study appear below:

TABLE 1.9

EFFECTS OF CHANGES IN THE HYPOTHESES ON THE FORECAST OF FIRM ELECTRICITY SALES BY HYDRO-QUEBEC IN QUEBEC

(in billions of kWh)*

Hypotheses	1985	1990	1996
Low penetration by gas	-2.7	-7.3	-13.1
Low demographic growth	-1.2	-2.6	-5.6
High penetration by gas and low demographic growth	-3.8	-9.8	-18.4
Oil crisis	+7.9	+9.2	+13.3
High demographic growth	+1.2	+2.8	+6.2
Oil crisis and high demographic growth	+9.2	+12.2	+19.8

* These figures are offered for information only. Unexpected variations in other factors studied such as economic growth, could also have a considerable impact on the actual growth in the demand for electricity.

I) CONCLUSION

A forecast of the demand for electricity has nothing prophetic about it: it is merely a tool, a step that must necessarily be taken before the Installations Plan can be formulated.

The forecast presented in the preceding pages is thus the one which Hydro-Québec considers to be most likely at this time. This forecast will be revised annually in the years to come.

The Installations Plan which follows from this forecast is presented in the next chapter. It is based on an average rate of growth in Québec's firm energy and power requirements of 6.0% from 1980 to 1996, but could be accelerated or slowed down as annual revisions indicate a larger or smaller rate of growth in energy and power requirements than the one used in making the forecast.

CHAPTER 2

THE INSTALLATIONS PLAN

1981 - 1990

A) THE NATURE AND CONTENT OF THE PLAN

This Installations Plan is based on the priority electricity requirements in Québec forecast until 1996.

It describes all the installations which Hydro-Québec must add to those already in place to be able to meet Quebecers' new requirements.

Included are the installations needed for the generation, transmission, subtransmission and distribution of electricity, the support installations indispensable for the administration and current operations of the utility and, finally, the installations necessary to implement the utility's technology program, i.e. research, development and demonstration facilities.

The plan also contains an estimate of the human resources and investments which will be needed to obtain these installations.

1) A Flexible Tool

Hydro-Québec's Installations Plan was designed dynamically. It is revised regularly every year so that its content and sequence can be adjusted to reflect new data and changes in the energy situation and the economy. The projects which now appear in the plan are the ones which in the light of the latest data appear to be most beneficial for the target period. However, later studies may reveal problems whose effect would be to increase estimated costs for one or more of the projects or make their implementation less desirable. In such a case, the project can be postponed to make room for another which earlier appeared less attractive but now seems more beneficial than the first one.

2) A Complete Tool

The development of Hydro-Québec's Installations Plan is the result of strategic considerations in both the studies which precede the choice of the projects as well as the selection of the particular equipment to be used. These considerations encompass not simply the technical and economic aspects of the projects but also such fundamental elements as the natural environment, political constraints, public concerns, financing possibilities and the availability of material and human resources.

The Installations Plan which is finally selected is thus the one which the utility considers best meets all these criteria.

B) STUDIES REQUIRED FOR THE INSTALLATIONS

For a project to be executed, a long series of studies must be undertaken in advance. Their purpose is to identify the characteristics and the conditions of execution of various development options and to choose the most beneficial of them.

Moreover, in parallel to these studies, Hydro-Québec consults with the general public and the various government departments, so that their concerns and requirements can be taken into account.

1) Study Criteria

Five major criteria guide these studies. They are:

- technical feasibility of the projects
- economic feasibility of the projects
- impact of the projects on the natural environment
- financing possibilities
- availability of human and material resources.

a) Technical Feasibility

When it has been determined that an installation requirement exists, whether it is for generation, transmission, distribution, support or some other purpose, several different possible solutions must be sought and analyzed for their technical feasibility, in terms of the data and the resources available.

b) Economic Feasibility

Once technically feasible solutions have been identified, the next task is to determine which one can be carried out at the lowest cost and will allow electricity to be provided at the lowest rates. This is what is called the "economic choice criterion."

More specifically, the installation which best satisfies the economic choice criterion is the one whose present value of total cost is the lowest. This cost includes the capital and operating expenses for the installation.

c) Environmental Impact

Environmental considerations are taken into account for each project. Before the decision to build a particular installation is reached, the utility makes sure that the environmental impact of the installation is generally acceptable. Then, at every stage in the study process and in the light of more specific data, Hydro-Québec modifies the projects to make them more acceptable and less disruptive to their environments. Thus, only those projects whose execution respects environmental protection standards appear on the Installations Plan.

d) Financing Possibilities

Although Hydro-Québec enjoys an excellent reputation in the financial markets, it can never be completely sure that the funds it needs will be available in the amounts needed at the times desired. Only specific financing studies make it possible to evaluate the likelihood of carrying out the projects called for by the Installations Plan. That is why Hydro-Québec devotes particular attention to its financing studies.

e) Availability of Human and Material Resources

Hydro-Québec must also make studies of the availability of human and material resources. This subject will acquire increasing importance in coming years because of the scope and variety of the planned installations.

2) Cost of the Studies

The cost of the studies required for the installations will amount to more than 500 million dollars during the next ten years, excluding the cost of studies associated with projects whose implementation is imminent. The cost of studies related to those projects has been included in the investment estimates shown in section H of this chapter.

C) GENERATING INSTALLATIONS

1) Generating Installations from 1981 to 1990

a) From 1981 to 1985

To meet forecast demand until 1985, Hydro-Québec will have five new generating stations available. Among them, the powerhouses in Phase I of the La Grande Complex account for an installed capacity of 10,269 megawatts and a production capacity of 62.5 billion kilowatthours.

After the commissioning of the last units at the LG-2 powerhouse, there will follow the units of the LG-3 powerhouse in 1982 and the LG-4 powerhouse in 1984. The planned addition of two extra units to LG-3 and LG-4 respectively has made it possible to postpone the construction of the LG-1 powerhouse. This project has now been included in Phase II of the construction of the La Grande Complex.

In 1983, Gentilly-2, the first nuclear generating station in commercial operation in Québec, will be commissioned. Because of the problems encountered during construction of this installation, the start-up period for Gentilly-2 will be longer than originally planned.

The construction of a back-to-back converter at the Châteauguay substation in 1984 will make it possible to count on 500 additional megawatts from the United States during peak periods and thus make it possible to reduce by that amount the power of the gas turbines which will have to be built in Québec to satisfy peak demand. This installation may also allow the utility to deliver energy to neighboring systems.

In 1985, additional equipment at Manic-5, which will be used for peak power, will make a further 988 megawatts of installed capacity available.

b) From 1986 to 1990

After Phase I of the La Grande Complex is in service, Hydro-Québec plans to commission the first units of Phase II of the complex: the LG-1 and Brisay powerhouses in 1989 and the Laforge-1 powerhouse in 1990.

Peak power requirements will be satisfied by gas turbines (including additions to the La Citière station) and the Delaney power station. The Delaney power station will be Québec's first pumped storage facility and will have a capacity of 2,550 megawatts. The remaining peak power requirements, some 3,100 megawatts, will be satisfied in large part by gas turbines.

Parallel to the completion of Phase II of the La Grande Complex is the planned start of commissioning of units at the Grande Baleine Complex in 1990. The site of the future complex is some 1,100 kilometres from Montréal, 200 kilometres north of the La Grande Complex. It will include three powerhouses: GB-1, GB-2 and GB-3, whose total installed capacity will be close to 2,900 megawatts. In addition to permanent facilities, the execution of this hydroelectric project will require the construction of both temporary and permanent infrastructures: more than 500 kilometres of roads, two airports, four workers' cities and two family villages. Since commissioning is planned for 1990, the construction of the road to GB-1 must begin in fall 1982 and major construction in summer 1985.

1981-1985

PROJECTS UNDER WAY FOR SERVICE BEFORE 1985

Power Station	In Service	Installed Capacity (MW)
La Grande complex — Phase 1		
LG 2	1979-1982	5,328
LG 3	1982-1984	2,304
LG 4	1984-1985	2,637
Manic 5 (new plant)	1985	988
Gentilly 2	1983	685
		11,942

1986-1990

PROJECTS NOT YET APPROVED FOR SERVICE BEFORE 1990

Delaney (pumped storage)	1987-1989	2,550
La Citière (gas turb. additions)	1986-1987	1,700
Other gas turbines	1988-1989	1,400
La Grande complex — phase II		
LG 1	1989-1990	1,140
Brisay	1989	400
Laforge 1 (LA 1)	1990	770
		7,960

1990-1996

PROJECTS NOT YET APPROVED FOR SERVICE BETWEEN 1990 and 1996

Power Station	In Service	Installed Capacity (MW)
Grande Baleine complex	1990-1991	2,896
GB 1		
GB 2		
GB 3		
N.B.R. complex (Nottaway, Broadback and Rupert) 9 power stations	1992-1998	6,780
Thermal or nuclear power station	1992 and 1995	1,800
Gas turbines	1992-1993	600
Peaking plant	1993-1994	1,400
La Grande complex — phase II		
Laforge 2 (LA 2)	1992	312
Eastmain 1 (EM 1)	1993	552
La Romaine complex	1994-1996	1,416
		15,756
	total	35,658

2) Generating Installations from 1991 to 1996

In the 90's, Hydro-Québec will commission the Laforge-2 and Eastmain-1 powerhouses, which are part of Phase II of the La Grande Complex, and the NBR Complex.

The NBR Complex is designed to exploit three major rivers: the Nottaway, Broadback and Rupert. The project which now seems most attractive consists in diverting the waters of the Nottaway and Rupert rivers into the Broadback, on which seven powerhouses will be built. In addition, two powerhouses with reservoirs will be built upstream of the diversions. So that commissioning can begin in 1992, road construction will have to start in October 1984 and work on the villages, camps, runways, airports and permanent infrastructures in June 1985.

3) Existing Generating Stations and Isolated Systems

Several projects of major renovations of existing generating stations offer possibilities of significant gains in both power and energy. In the next ten years, the replacement of existing hydraulic turbines will provide a gain of one hundred megawatts.

Plans also call for the possibility of installing a 20-megawatt powerhouse at Lac Robertson to supply the isolated La Tabatière system on the Lower North Shore. Investments are also planned for the Iles-de-la-Madeleine (Magdalen Islands). The present diesel units will be adequate to meet the needs of the residents of the islands until 1985.

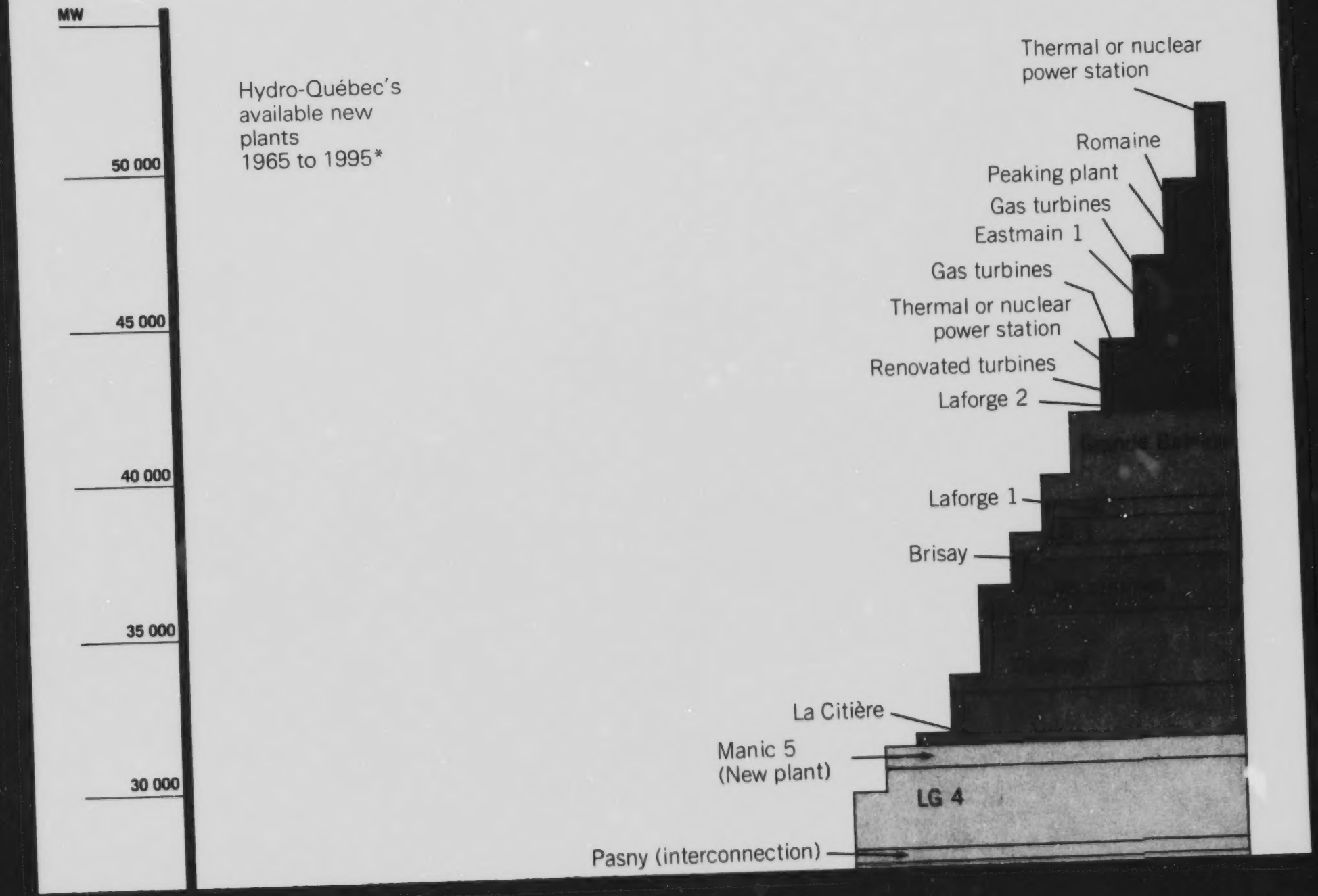
The isolated systems of the Lower North Shore located west of Natashquan will be integrated into the main system. By virtue of the James Bay and Northern Québec Agreement, the systems in New Québec will be progressively taken over, starting in 1983.

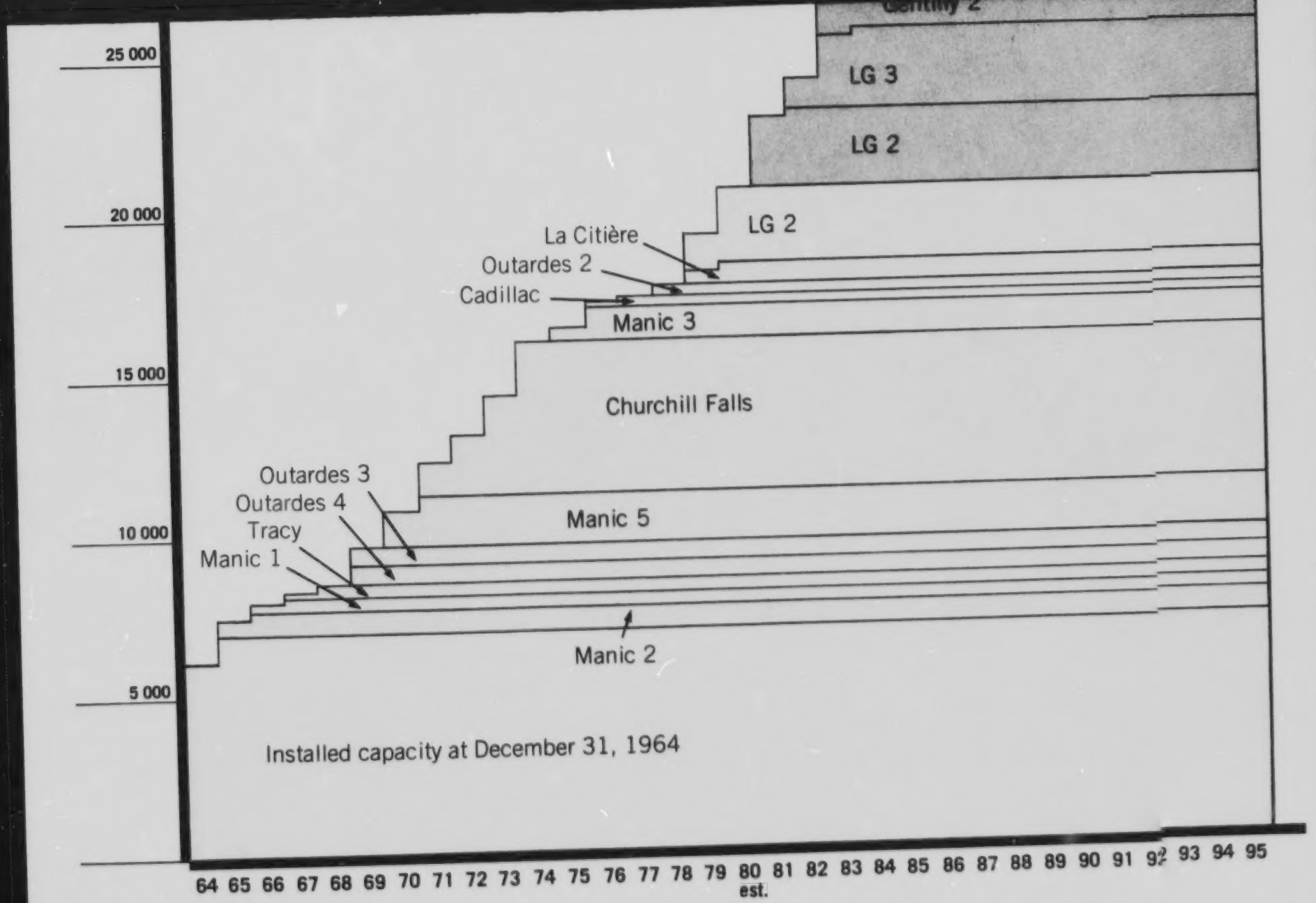
4) Electricity Surpluses Anticipated between 1981 and 1990

Hydro-Québec forecasts annual electricity surpluses varying from 6 to 24 billion kilowatthours between now and 1988. These surpluses are mainly due to the slower growth in demand for electricity anticipated for the 1981-90 period.

Between 1981 and 1984, Hydro-Québec will be able to sell surpluses of 12.5 billion kilowatthours annually. In mid 1984, when the back-to-back converter at the Châteauguay substation is put in service, this capacity will rise to 19.5 billion kilowatthours. Finally, a new interconnection with New Brunswick may bring surplus sales up to 23 billion kilowatthours.

After 1988, little surplus is anticipated. At this time, installed interconnections will serve their real purpose, which is to sell occasional and unexpected electricity surpluses in more remunerative markets and make exchanges with our neighbours on a daily or weekly basis.


MW
50 000
45 000
40 000
35 000
30 000
Hydro-Québec's available new plants 1965 to 1995*
Thermal or nuclear power station
Romaine
Peaking plant
Gas turbines
Eastmain 1
Gas turbines
Thermal or nuclear power station
Renovated turbines
Laforge 2
Laforge 1
Brisay
La Citière
Manic 5 (New plant)
LG 4
Pasny (interconnection)



*Including contractual agreements with neighboring systems

D) TRANSMISSION, SUBTRANSMISSION AND DISTRIBUTION INSTALLATIONS

1) Transmission and Subtransmission Installations

Transmission installations are dependent on generating installations. It is impossible to think of generating electricity without at the same time thinking of how it will be brought to consumers. Since the generating stations which will come on stream in the 80's are very far from consumption centres, the transmission system to be built will also be a major undertaking.

Before the transmission line corridors are determined, Hydro-Québec undertakes numerous technical and economic studies, just as it must for generating installations. Such studies have shown that to guarantee the reliability of electrical transmission from such remote generating centres as the La Grande Complex to the major consumption centres, three corridors are required: two toward Montréal and the other in the direction of the Saguenay and Québec City areas. It is not hard to imagine the danger in having a single corridor to bring all the electricity from James Bay, as well as the burden this corridor would impose on the regions it crossed.

With this in mind, the extremely detailed studies used to select the site of the corridors deal in particular with the physical and human environment.

During these studies, a large number of factors are taken into consideration. These include the use of the land being crossed, the density to the population and so on. Governments and citizens are consulted, individually and in organized groups. Since the land to be crossed during the 80's is frequently farm and recreational land, Hydro-Québec cannot claim that the transmission of electricity will have absolutely no impact. What the utility can do is make sure that the corridors selected are those where the impact is least.

All in all, Hydro-Québec will not shirk its responsibility to bring electricity to consumers with the greatest respect for the natural and human environment. For example, it has already planned in coming years to build increasingly larger capacity lines, so that their number and thus their environmental impact is reduced. The appearance of the towers will be improved near cities. And the underground high voltage system, which powers the distribution substations inside the major cities, will be significantly expanded.

Present and Anticipated Situation

At this time, 6,800 kilometres of 735-kilovolt transmission lines and 17 substations provide the transmission of electricity from generating stations whose available capacity is near 21,000 megawatts.

Between 1981 and 1990, Hydro-Québec's generating installations plan calls for the commissioning of generating stations whose total installed capacity will be about 19,000 megawatts -- nearly the equivalent of what is already available. To bring the energy from these new power stations to the consumption centres, some 4,900 kilometres of 735-kilovolt lines and 16 substations must be added to the current system. Here is a closer look at what is involved:

Between 1981 and 1985

Of the 4,900 kilometers of lines planned for the 80's, 3,300 will be used to connect the generating stations of Phase I of the La Grande Complex -- LG-2, LG-3 and LG-4 -- to consumption centres. The corridors needed for these lines have already been approved. Nine of the 16 planned substations will also be built during this period.

Between 1986 and 1990

To connect Phase II of the La Grande Complex -- the LG-1, Brisay and Laforge-1 powerhouses -- and the Grande Baleine Complex to consumption centres, 1,300 kilometres of lines and three substations must be built.

Studies are already under way on the lines and substations for the Grande Baleine and NBR Complex powerhouses, which are planned for commissioning during the 90's.

2) Distribution Installations

Electricity will be transported from the distribution substations to the customer by a 25-kilovolt line system. The design of the new 315-25 and 230-25 kilovolt distribution substations is adapted to their environments.

The capacity of the transformer substations will be increased in major urban centres and large cities so that their number can be decreased. In rural areas, landscaping will be increasingly employed in building substations.

Hydro-Québec is planning to install automated operating centres and to automate the system itself starting in 1984. All these measures will make it possible to manage the system efficiently and improve the continuity of service.

E) SUPPORT FACILITIES

Support facilities are all those installations associated with the administration of the utility (administrative buildings, transport, office equipment and computers) and telecommunications installations not linked to the system.

The programs for the acquisition of these facilities are drawn up to reflect the ancitipated increase in numbers of employees, administrative building occupancy standards, the growth of the utility's business, the expansion of markets for certain products and the utility's general policies.

The period from 1981 to 1990 will see the construction of a new head office and the renovation of a good number of administrative buildings. There will also be increased use of computerized facilities in management and office work.

F) TECHNOLOGY PLAN INSTALLATIONS

The technology plan is of strategic importance for Hydro-Québec because the utility must constantly make use of state-of-the-art techniques. Moreover, because electricity is destined to play an enhanced role in Québec's energy supplies, the utility must maintain its leading edge in the development of energy technologies.

The technology plan includes six program areas:

- conventional sources of electricity;
- new sources of electricity;
- transmission and distribution systems;
- system analysis and automation;
- energy use and conservation;
- general technologies.

The first four programs are intended to improve system operating techniques; the fifth involves energy use and conservation; the last deals with research which can be used by all the programs.

1) Conventional Sources of Electricity

Work in this program mainly involves hydroelectric energy, conventional thermal energy (using oil or coal) and nuclear energy.

Its purpose is to increase the efficiency, reliability, safety and economic performance of generating installations and improve their integration in the environment.

2) New Sources of Electricity

"New" sources of electricity are those which are not yet commercially exploited in North America. Hydro-Québec will study those which offer the greatest advantages for Québec. These are biomass (peat and wood), wind energy and nuclear fusion. Research will also be done on energy storage.

3) Transmission and Distribution Systems

Research on the transmission of energy on overhead high and extra high voltage lines is particularly important because of the remote locations of the major power stations. It is intended to increase the efficiency of energy transmission, the reliability of the lines and equipment and the integration of the lines and substations in their environments.

In the area of energy distribution, the utility will devote its efforts to improving current operating techniques and developing new ones for overhead and underground distribution.

4) System Analysis and Automation

The objective of this program is to facilitate system planning and operation by developing and improving analysis methods and to integrate the use of microprocessors and microcomputers in the operation of the system.

5) Energy Use and Conservation

This program deals with the use of solar energy, heat pumps, thermal discharges, synthetic fuels and consumption management. Also included is research on energy conservation in Hydro-Québec's buildings and transport equipment.

6) General Technologies

This program includes the work which will be applied in all the preceding programs, e.g. materials technology.

G) HUMAN RESOURCES

Human resources assigned to carrying out the Installations Plan will increase from 16,000 man-years in 1981 to 34,500 in 1990. The workers will be hired by Hydro-Québec, la Société d'énergie de la Baie James, consulting firms and contractors (see Fig. 2.1). Generating equipment will require nearly 65% of this work force.

1) Hydroelectric Powerhouses

Two factors largely determine work force requirements for base-load hydroelectric generating stations: the simultaneity and multiplicity of worksites.

a) Simultaneity of Worksites

In the future, Hydro-Québec will have to develop several rivers simultaneously to meet electricity requirements. In the mid 80's, the worksites of Phase II of the La Grande Complex and those of the Grande Baleine Complex will be in full swing, while work at the NBR and La Romaine Complex sites will just be beginning.

b) Multiplicity of Worksites

Except for the worksites of the La Grande, Grande Baleine and NBR Complexes, most future generating stations will have less than 1,000 megawatts of power. This means that there will be more worksites and therefore an increase in the number of man-hours required to complete the projects. As an example, for the Manic-3 powerhouse the ratio of man-hours per megawatt of installed capacity was 17,750, whereas for the La Romaine Complex, which is to be commissioned in 1994, this ratio is estimated to be 28,650, an increase of 60% in the work force per unit of capacity.

From 1981 to 1985, the period which corresponds to the completion of Phase I of the La Grande Complex, there will be a progressive decrease in the work force assigned to base-load hydroelectric projects. However, starting in 1985, when work is at its peak, the work force will increase once more, reaching nearly 25,000 in 1990 (see Table 2.2). It should be noted that 17,000 workers were at work on the construction of the La Grande Complexe - Phase I in 1979.

2) Thermal and Nuclear Power Stations

As far as thermal and nuclear power stations are concerned, the drop in the work force forecast for 1983, 1984 and 1985 corresponds to the end of work on the Gentilly-2 worksite.

After 1985, the resumption of work may require some 1,700 employees, equivalent to the number employed during peak activity at Gentilly-2. It is possible, however, that the slowdown of activities from 1983 to 1985 will make such resumption difficult.

Figure 2.1

Breakdown of work force needs
by type of installation
1981 to 1990

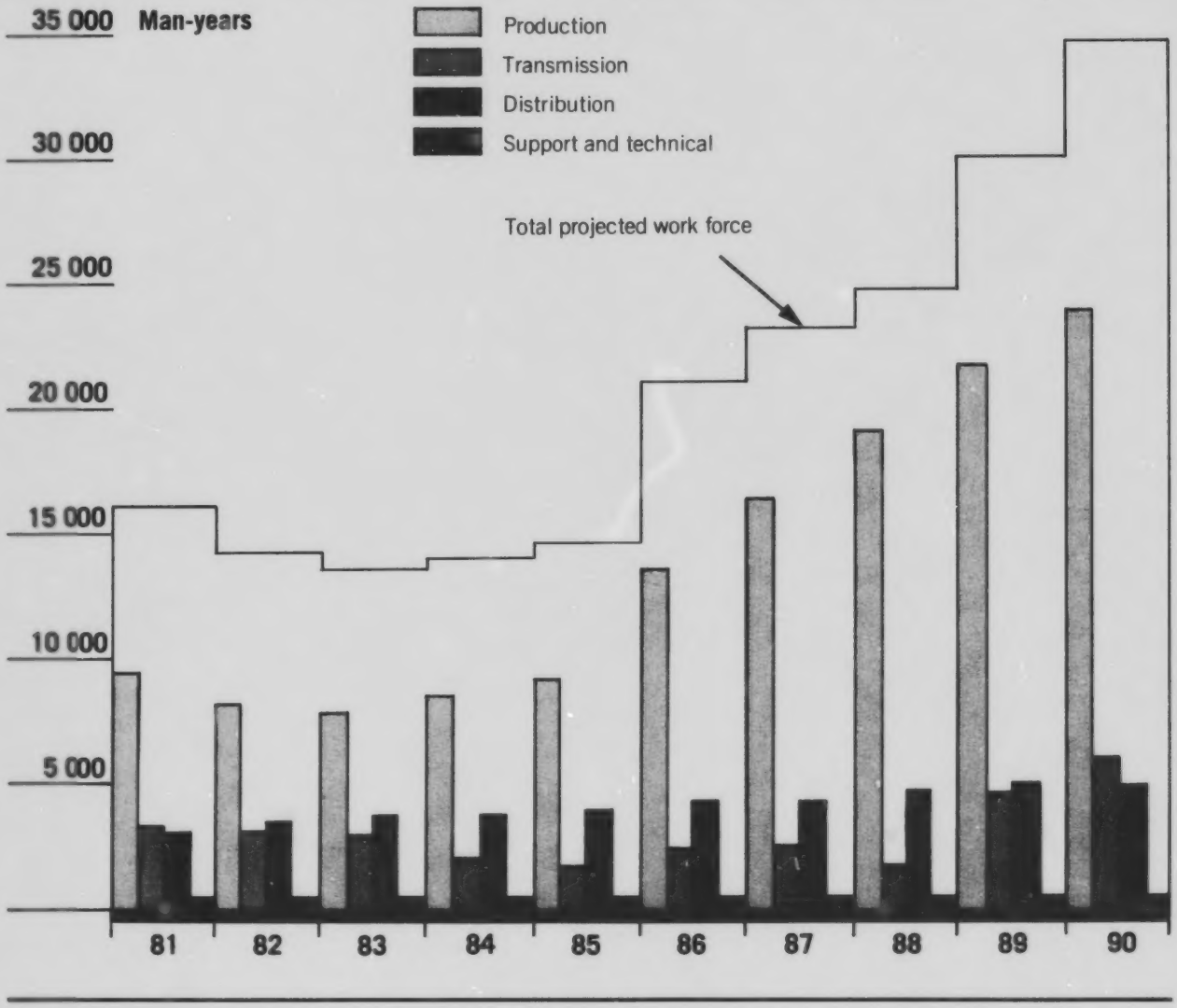


TABLE 2.2

PEAK WORK FORCE* AT GENERATING FACILITY CONSTRUCTION SITES

	BASE-LOAD HYDROELECTRIC	NUCLEAR AND THERMAL	PEAK EQUIPMENT	SMALL WORKSITES	TOTAL PEAK WORK FORCE AT THE SITES
1981	9,550	550	750	300	11,100
1982	7,200	200	900	400	8,700
1983	5,200	150	1,900	450	7,700
1984	4,400	150	3,050	500	8,100
1985	5,300	-	2,400	600	8,300
1986	10,100	300	2,350	650	13,400
1987	13,500	900	1,650	750	16,800
1988	16,300	1,500	900	900	19,600
1989	21,900	1,700	400	1,000	25,000
1990	24,600	1,900	100	1,100	27,700

* Hydro-Québec, S.E.B.J. and contractors

H) INVESTMENTS REQUIRED

Total investments which Hydro-Québec will have to make during the next ten years to implement its Installations Plan will amount to 55.5 billion dollars. This amount includes the cost of installations which will be built or completed before 1990 and that of installations which will not begin operation until after 1990 but whose construction must be begun during the 1981-1990 period.

Estimated investments reflect increases in costs due to inflation and interest expenses charged to projects until they are commercially operational. Inflation rates used are those forecast by Hydro-Québec and vary according to the nature of the installations. An annual rate of 11% was used for interest.

As shown on Figure 2.2, the generating installations account for 72% of total anticipated investments, while transmission and distribution installations require 14% and 11% of investments respectively. Support facilities and installations required for the technology plan account for 3% of the total investments.

The greater share of investments for generating facilities, amounting to 40.0 billion dollars, is devoted to hydroelectric power stations. During the 1981 to 1990 period, the development of major hydroelectric complexes (Phases I and II of the La Grande, Grande Baleine, Nottaway-Broadback-Rupert) and the installation of the transmission system required to bring what they generate to the main consumption centres will still be the core of Hydro-Québec's development activities.

Growth in Total Investments

Annual growth in total investments will vary during the period being considered.

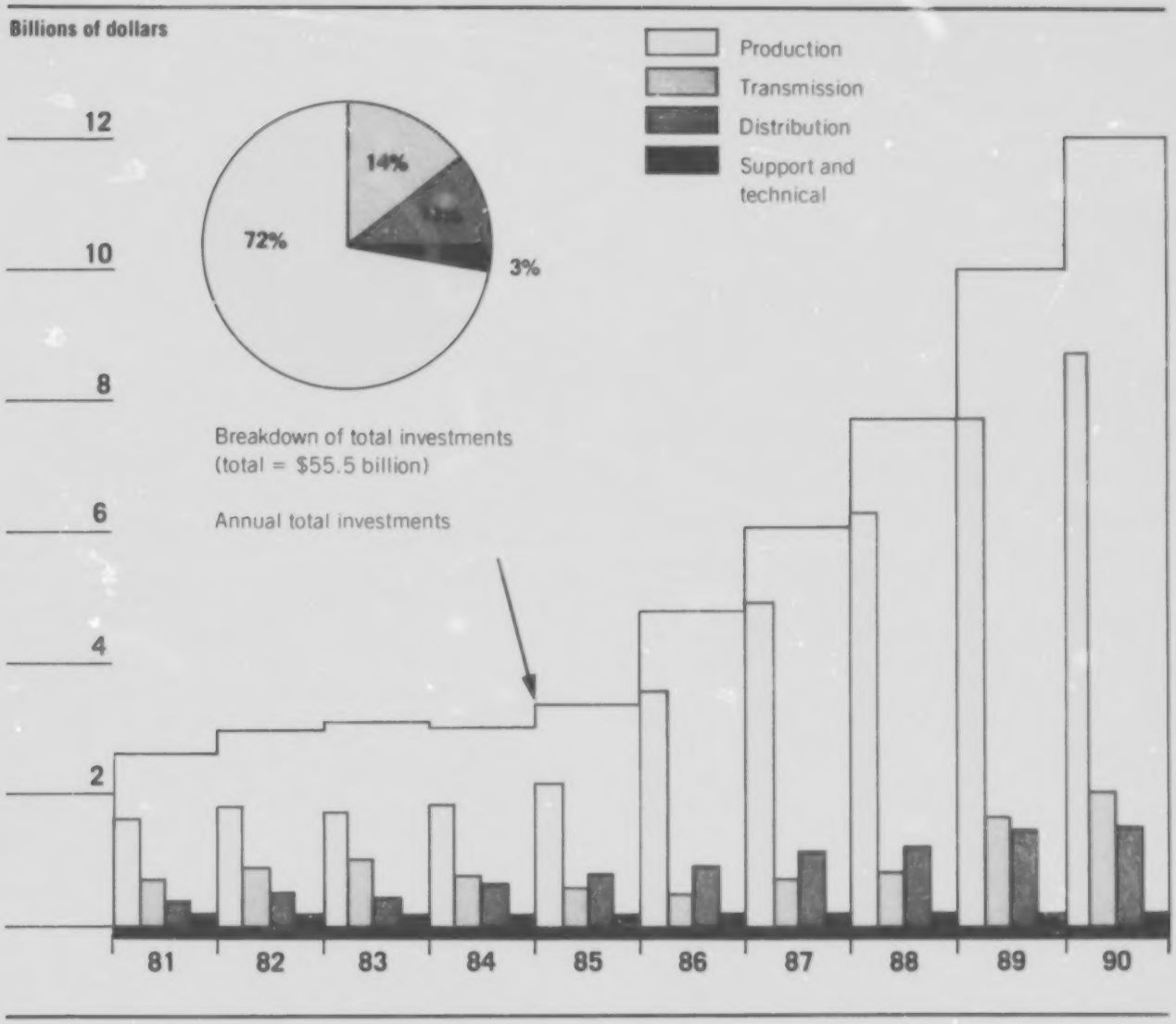
From 1981 to 1985, investments will remain relatively stable at about 3 billion dollars per year. During this period there will be little investment in new base-load energy generating installations. Power generated by Phase 1 of the La Grande Complex, now under construction, will satisfy all base-load energy requirements until 1988. Most of the construction starts planned between 1981 and 1985 are for peak power stations which require much smaller investments than base-load stations as well as less in the way of transmission lines, because they are built near consumption centres.

However, after 1986, overall investments will increase by an average of 30% per year. Starting that year, it will be necessary to undertake construction of new hydroelectric complexes, to be used to satisfy additional base-load energy requirements for the 1990-1996 period, at the same time as other peak power generating stations. The hydroelectric complexes to be built at this time will be more expensive than those constructed earlier. This increase in costs, added to increases due to inflation and the growth of electricity requirements, explains the significant increase in investments from 1986 on.

Figure 2.2 shows a breakdown of annual investments by type of installation (generation, transmission, distribution, support and technology). It should be stressed that investments planned for implementing the technology plan do not include the operating expenses associated with the implementation of the plan. These amount to 815 million dollars during the 1981 to 1990 period.

Figure 2.2

Breakdown of total annual investments by type of installation 1981 to 1990



I) ELEMENTS OF A FINANCING STRATEGY

The financing conditions of the Installations Plan are subject to even greater uncertainty than either the demand forecast or the plan itself. Indeed, financial markets experience marked variations which are difficult if not impossible to predict more than several years in advance.

Thus, the financing strategy only covers the next five years, and it is only defined in its broad outlines. As the variables involved become better defined, it will be possible to expand the strategic horizon to cover the second half of the decade.

Essentially, the financial strategy from 1981 to 1985 will consist in determining which portion of Hydro-Québec investments is to be financed by loans and which by funds generated by the utility.

Hydro-Québec considers that internal financing of its investments in the next five years should be close to 30%. This proportion is a reasonable minimum if the borrowing possibilities are considered.

J) CONCLUSION

As is apparent, the Installations Plan is based above all on the development of Québec's hydroelectric resources.

Other options, some of which are the subject of research and study programs, may gradually expand the range of sources of electricity when their integration in Hydro-Québec's operating installations proves economical.

The next chapter analyses the larger and smaller rivers which it will be both possible and economical to develop in the 90's, briefly examines the possibilities offered by thermal and nuclear sources and provides a summary of the possibilities offered by alternative energy sources.

CHAPTER 3

OPTIONS FOR THE FUTURE

Although the 80's have scarcely begun, we must already prepare for the challenges of future decades. While it is much too early to draw up a specific plan of action, Hydro-Québec can already start to identify the solutions from which it will have to choose, if it is to be able to fulfill its mandate after 1990.

To satisfy future requirements, Hydro-Québec will exploit Québec's hydroelectric resources and other sources of electricity, such as thermal and nuclear energy and alternative energy sources.

A) QUEBEC'S HYDROELECTRIC POTENTIAL

The rivers of Québec can be divided into two categories: large rivers, whose potential is more than 100 megawatts, and smaller rivers, which have less potential.

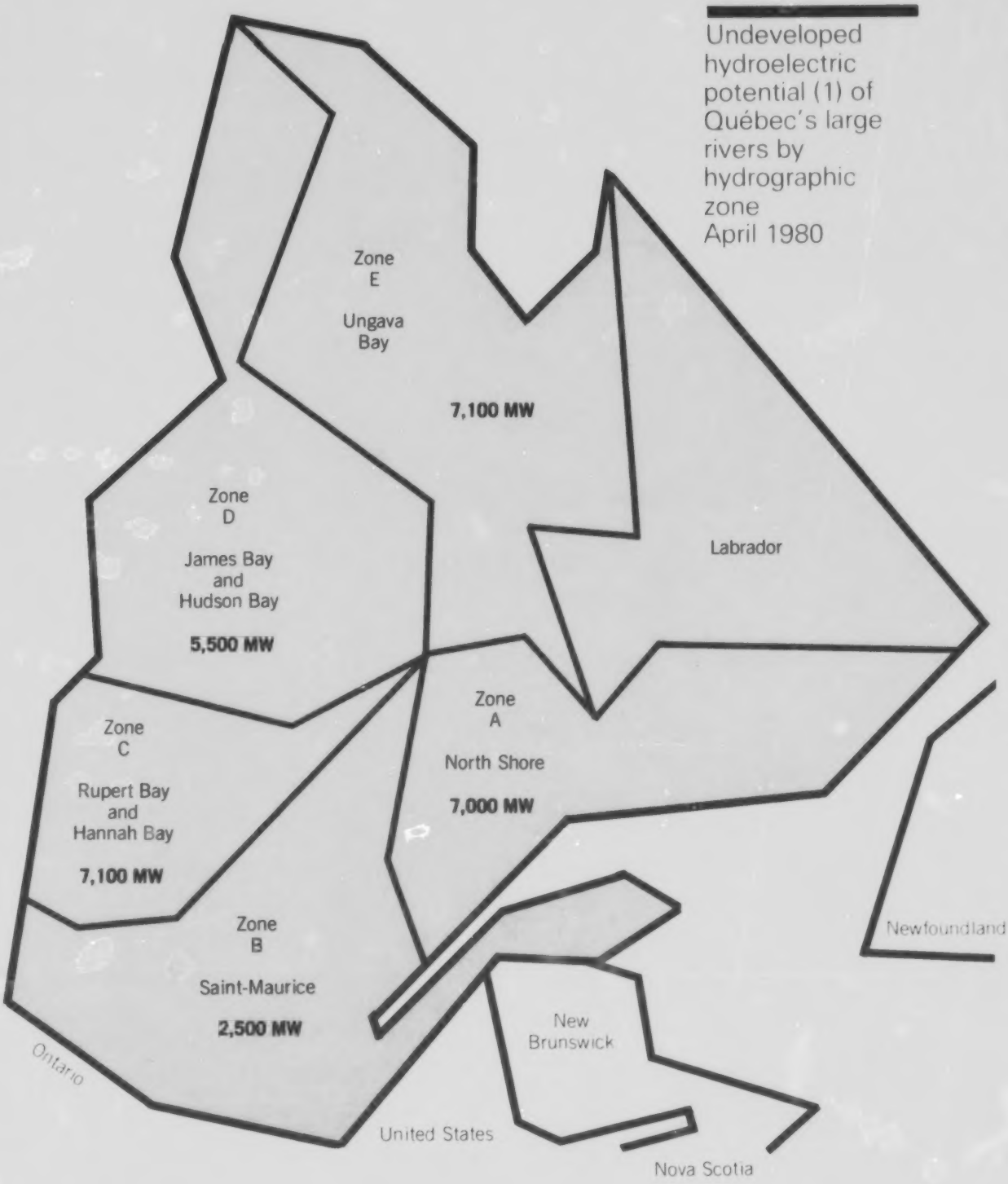
1) Large Rivers

In 1985, when phase I of the La Grande Complex is completed, the potential of Québec's large rivers still open for development will be around 29,000 megawatts (base-load power) divided among 32 projects (see Fig. 3.1).

However, not all this potential can in fact be tapped. Technical, environmental, political, legal and social constraints limit access to some of these hydroelectric resources. Moreover, compared to competing sources of electricity, some rivers will be too expensive to develop.

Figure 3.1

Undeveloped hydroelectric potential (1) of Québec's large rivers by hydrographic zone
April 1980



(1) Potential calculated on the basis of annual energy production and a utilization factor of 80%.

It is therefore worthwhile to evaluate what proportion of the hydroelectric potential can be economically developed in the long term, even if only a rough estimate of the cost of development is available. To make such an evaluation, the cost of the energy generated by the hydroelectric powerhouse is compared with the energy generated by a reference power station.

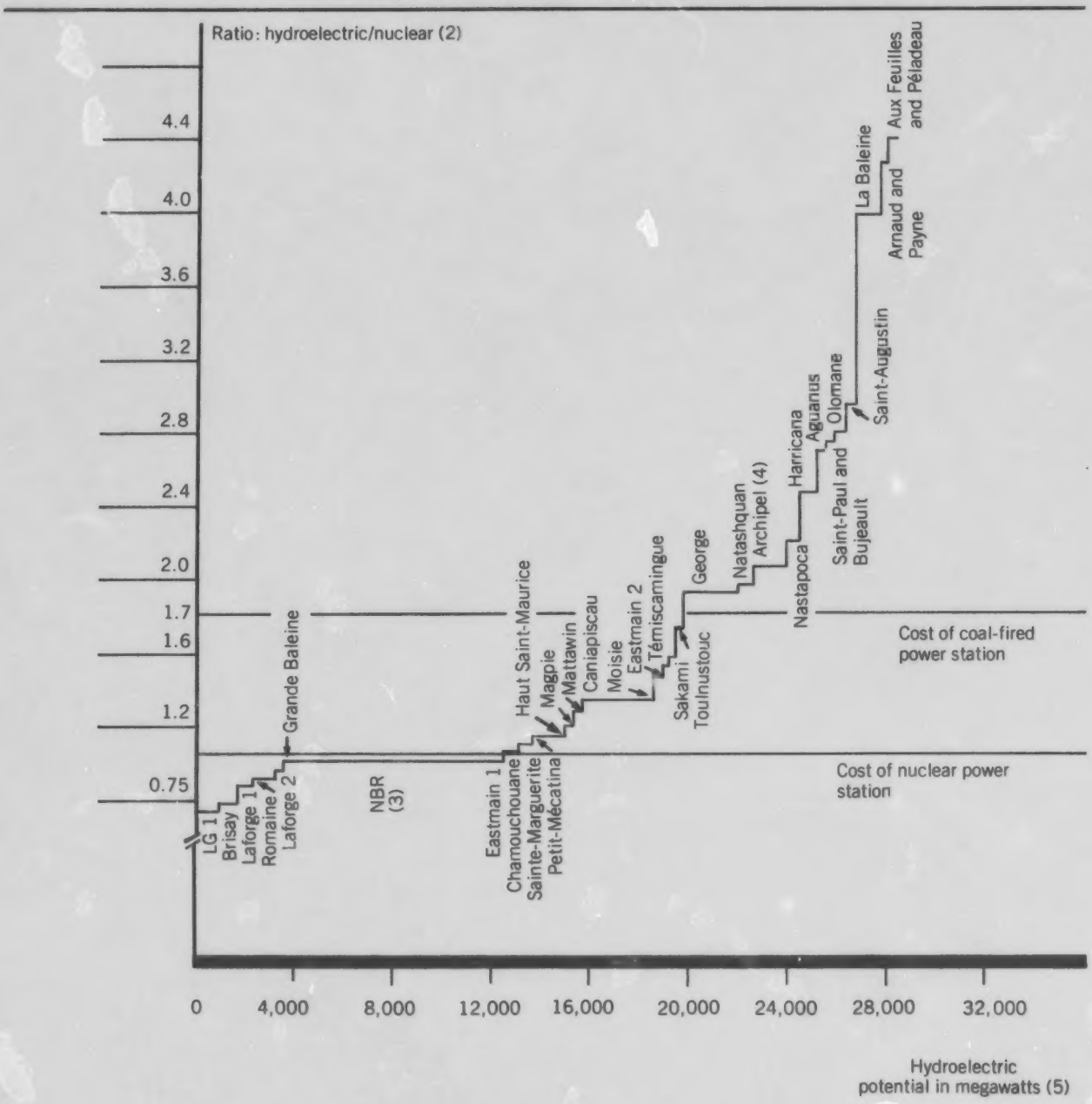
In most developed countries, particularly those which have no local coal production, nuclear energy is the main source of electrical energy which can be exploited in the long term. It is this form of energy which has been used as the reference source in evaluating the economic feasibility of Québec's hydroelectric potential. The reference unit selected is an 850-megawatt CANDU-type nuclear power plant, using natural uranium as fuel and heavy water as the coolant and moderator.

The results of this comparison appear on Figure 3.2, showing a breakdown of hydroelectric potential in Québec not yet harnessed according to development cost.

Figure 3.2

Breakdown of Québec's undeveloped hydroelectric potential (1) in 1985, according to development costs

(1) Only rivers with a potential of more than 100 megawatts.
(2) The cost of each project was established for a commissioning date in 1995; it includes maintenance, operating and transmission costs and reserves and has been adjusted for a utilization factor equivalent to comparable nuclear plant.
(3) Broadback II alternative with addition of R-10 and R-11. This cost corresponds to the average cost of development in three independent phases (January 1980 estimate).
(4) A preliminary estimate of the project with only one power station on Lake St. Louis (730 MW; 5.7 billion kWh) gives a coefficient of 1.46 in relation to nuclear plant.
(5) Potential calculated on the basis of annual energy production and a utilization factor of 80%.



This figure indicates that as now understood, Québec's hydroelectric potential which would be more economic to develop than nuclear power amounts to 12,000 megawatts. This potential includes all projects whose ratio compared to the cost of a nuclear power station is less than 1.00. The potential rises to 15,800 megawatts if those projects which would cost up to 25% more than the nuclear option are also included. Finally, if all Québec's hydroelectric potential were developed, the most expensive projects would cost more than four times as much as nuclear energy.

2) Smaller Rivers

Smaller rivers are those which offer 100 megawatts potential or less. There are about 400 such rivers in Québec, for a total potential of about 10,000 megawatts. These rivers can be divided into two categories: developable potential and theoretical potential.

a) Developable Potential

The developable potential includes all the sites which had been studied by electricity distribution companies in Québec before they were nationalized to meet their requirements as well as those whose technical characteristics have been studied more recently by Hydro-Québec, using a preliminary evaluation process. This category contains about 305 sites divided among one hundred or so rivers and offers a potential of a little more than 5,000 megawatts.

b) Theoretical Potential

The theoretical potential includes all rivers whose natural physical features have been analyzed without the site or nature of construction necessarily having been determined. This category includes some 301 rivers, offering a potential of about 4,800 megawatts.

Hydro-Québec is concentrating its efforts on developable potential because it offers the best prospects for development.

Harnessing smaller rivers may prove to be a convenient way of replacing thermal installations in isolated systems. New design and construction methods will be required, however, to reduce the very high costs of multiple worksites.

In any case, the utility plans to take advantage of certain sites in the integrated system which are already provided with elements making them attractive at the outset. These include dams which were built for such purposes as forming the forebay of a major complex or controlling floods or simply as part of a hydroelectric development which has since been withdrawn from service.

B) OTHER SOURCES OF ELECTRICITY

1) Nuclear and Thermal Power Stations

Hydro-Québec is aware of the many aspects of the nuclear controversy. The utility has no firm position on the question but is staying up-to-date on all new data in this field. The Installations Plan calls for the Gentilly-2 power station to be completed in 1983. Hydro-Québec is continuing studies in the nuclear field as well as studies related to thermal power plants which use coal for fuel.

2) Alternative Energy Sources

As far as alternative energy sources are concerned, Hydro-Québec is pursuing a dual goal: to develop economic and reliable techniques for generating electricity from local energy sources which have significant potential and to integrate these sources in conventional generating methods.

From this perspective, the most attractive sources are biomass, solar energy, wind energy and thermonuclear fusion. The storage of electrical energy is also being studied.

a) Biomass

Biomass offers attractive potential in Québec, particularly as it involves peat and wood, to which forest wastes, damaged forests and perhaps even fast cropping forests can be added.

Biomass can be exploited by simply burning it in thermal generating stations or by transforming it into gas or liquid fuel to supply diesel or turbine power stations. Projects for each of these applications are now being studied at Hydro-Québec.

b) Solar Energy

Solar energy offers possible applications in heating buildings and water and, in the long term, in the generation of electricity.

The main goal Hydro-Québec has set in this field is to identify the most attractive applications, expand research and help Québec industry profit by jointly developing solar equipment best adapted to Québec's climatic conditions.

c) Wind Energy

Although Québec has large wind potential, the technical reliability and profitability of large wind mills has not yet been established. For isolated systems like the one on the Iles-de-la-Madeleine, the generating of electrical energy by wind mills may in the near future become competitive with diesel power stations.

At this time Hydro-Québec has two research and testing stations, with a total capacity of 270 kilowatts. One is located on the Iles-de-la-Madeleine and the other at the IREQ laboratories in Varennes.

d) Thermonuclear Fusion

The possibilities offered by thermonuclear fusion are very great. In a few years time it will be possible to demonstrate that controlled nuclear fusion is feasible. The development of the first commercial reactor is anticipated for the beginning of the 21st century. Hydro-Québec is now involved with INRS, the Université de Montréal, Canatom Ltd. and MPB Technologie Inc., in a joint project to design, build and operate a Tokamak reactor at Varennes.

e) Energy Storage

Various processes for storing electrical and thermal energy are now being studied. An agreement on storage batteries has been signed by the French oil company ELF-Aquitaine, the Agence nationale de valorisation de la recherche (ANVAR) and IREQ, to pool the work of research teams and speed up the development of this technology. By 1990 this agreement may lead to Québec industry selling new batteries on Canadian and American markets and thus contributing to the development of commercial electrical vehicles.

Storage in hydrogen form may also experience major growth. In collaboration with the Noranda group, Hydro-Québec will build an experimental liquid hydrogen production plant at the IREQ site in Varennes. In addition to allowing the study of new uses of electricity in the field of transportation, this project will open the way for the development of new techniques of storage and the manufacture of synthetic fuels and heavy water.

C) CONCLUSION

Although Québec's hydroelectric potential is adequate to meet its electricity requirements until the mid 90's, this potential is not inexhaustible. Thus it is necessary even now to think of how to meet the demand for electricity at the end of this century and the beginning of the next.

Unless there are spectacular and unexpected technological breakthroughs, no new form of energy will be economically exploitable in time to take over from hydroelectricity. Thermal or nuclear power stations, which have their own features, will probably have to fill the gap.

Indeed, although it may be possible to make the operation of a coal-fired thermal power station environmentally acceptable, this source of electricity would be very expensive. The fact that Québec does not have coal deposits reduces the economic spinoffs of such equipment even more.

Nuclear energy would be less expensive than conventional thermal energy and its economic impact would be much greater. However, this technology continues to cause concern among the people of Québec.

When the time comes, all these factors will have to be carefully weighed for an enlightened choice to be made.

GLOSSARY

This glossary defines the concepts and the main terms used in the document.

The glossary starts with an explanation of the basic concepts arranged under subject headings. This is followed by an alphabetical list of the technical and specialized terms together with their definition and their symbol, as applicable.

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BASIC CONCEPTS

ELECTRICITY DEMAND

In Hydro-Québec's terminology, electricity demand represents the priority requirements; it is expressed in power (kilowatts) and energy (kilowatthours).

THE PRIORITY REQUIREMENTS

Priority requirements are understood to mean the electricity requirements which Hydro-Québec must satisfy by virtue of its mandate, i.e. the requirements of the municipalities, industrial or commercial firms and citizens of Québec. The priority requirements exclude sales of surplus electricity and deliveries outside Québec.

POWER AND ENERGY

- Power is the rate at which work is done.

  Example: A generator with an output (or capacity) of one million watts can produce more electricity than a generator with an output of four hundred thousand watts.

- Energy is the product of power and the time during which this power is used.

  Example: A generator with a capacity of one million watts operating for one hour produces one million watthours of energy.

  When the generator is operated for ten hours it produces 10 million watthours.

When planning the generating facilities of Hydro-Québec the distinction between power and energy is of prime importance. During a period of one hour a generator with a capacity of one million watts cannot produce more than one million watthours. If ten million watthours are to be produced during the same period of one hour, ten generators with a capacity of one million watts each would be needed.

BASE-LOAD DEMAND AND PEAK DEMAND

When Hydro-Québec evaluates the electricity demand of Québec consumers it makes a distinction between base-load demand and peak demand.

BASE-LOAD DEMAND

Base-load demand represents the number of kilowatts (thousands of watts) which are required continuously. This demand could be said to correspond to the minimum number of kilowatts which must be available throughout the year.

PEAK DEMAND

Peak demand represents the number of kilowatts required for short periods of time only, when the electricity requirements of consumers reach their highest peaks.

The power stations of Hydro-Québec designed to meet the peak demand are usually different from those intended to satisfy the base-load demand.

FIRM ELECTRICITY

Firm electricity is the electricity normally furnished by the supplier.

SURPLUS ELECTRICITY

Surplus electricity represents the excess electricity which can be sold or bought without guarantee concerning continuity of supply.

Note: Surplus electricity can be sold to certain industrial customers, to neighboring systems or for export.

SALES

The Hydro-Québec sales represent the quantities of electricity supplied against payment.

Note: Sales can be of two types:

- firm electricity or
- surplus electricity

TECHNICAL AND SPECIALIZED TERMS

BACK-TO-BACK CONVERTER	An installation which converts alternating current into direct current, then converts it back into alternating current.
BASE-LOAD POWER STATION	A power station which is normally operated to generate the base-load power of an electrical system and which must therefore maintain constant production.
DISTRIBUTION (- installations)	All the substations and lines which enable electric power to be delivered to the consumers.
ECONOMIC POTENTIAL	The hydraulic potential which could be developed under economically acceptable conditions.
ELECTRICAL SYSTEM	A structured entity of installations which can comprise the electricity production, transmission, subtransmission and distribution equipment.
HYDROELECTRIC POTENTIAL	The hydroelectric energy which could be produced in a basin, region or territory at locations considered possible by using all the water resources and all the means that can be considered technically feasible.

HYDROELECTRIC POWER STATION	A power station which produces electrical energy by means of hydraulic energy. The water rotates turbines coupled to generators.
HYDRO-QUEBEC'S SYSTEM	All the electrical systems belonging to Hydro-Québec.
INSTALLED CAPACITY	The total rated capacity of the generators of a power station or electrical system, the rated capacity being the figure for the useful output quoted in the specifications of a machine or apparatus.
INTEGRATED SYSTEM	All the electrical systems of Hydro-Québec interconnected either directly or by means of neighboring electrical systems.
INTERCONNECTED SYSTEMS	Systems linked together by means of one or more interconnections.
INTERCONNECTION	Link which allows for the movement of energy between electrical systems in both directions.

INTERNAL FINANCING	The ratio which represents that part of investments provided from the resources generated by the operations of an enterprise. In the case of Hydro-Québec this means resources provided by operations less loan repayments, divided by investments.
ISOLATED SYSTEM	System which belongs to Hydro-Québec but does not form part of the integrated system, i.e. it is not connected to the other systems of Hydro-Québec.
LOSSES	The amount of electricity consumed by the transmission, transformation and distribution equipment as the electricity is carrried to the consumers.
MAIN SYSTEM	Hydro-Québec's electrical systems which are interconnected without the aid of neighboring electrical systems.
NEIGHBORING SYSTEM	System outside Québec or a Québec system which does not belong to Hydro-Québec but which is taken into account in the planning and management of Hydro-Québec's system.

PEAK-LOAD POWER STATION

A power station which has to operate during certain periods, usually at peak hours.

PRESENT VALUE

Cost at which a series of investments and operating expenses spread in time have been converted into a single amount on a given date to enable a comparison to be made among various projects which involve investments and operating expenses differently distributed in time.

PUMPED-STORAGE POWER STATION

A hydroelectric power station which has two reservoirs, an upper and a lower reservoir, connected by a powerhouse. When electricity demand is low the turbo-alternator units of such a station consume electricity by operating as motors and pumps to return the water from the lower to the upper reservoir. The units operate as turbines and generators to produce electricity, usually at peak hours, by allowing the water to flow to the lower reservoir.

SUBTRANSMISSION
(- installations)

All the substations and lines which link the transmission substations to the distribution systems; these installations distribute power at the regional level.

THERMAL POWER STATION

A power station which produces electrical energy by means of thermal energy.
Note: General term which designates conventional thermal power stations (coal, oil, etc...), nuclear and diesel stations, gas-turbine stations and solar and geothermal stations.

TRANSMISSION
(- installations)

All the substations and lines used to transmit large quantities of electricity over long distances.

UNDEVELOPED POTENTIAL

Hydroelectric potential which has not yet been exploited.

VOLT

The unit of voltage and of potential difference.

WATT

The unit for measuring electrical power.
kW = kilowatt (thousand watts)
MW = megawatt (million watts)

WATTHOUR

A practical unit for measuring electrical energy.
kWh = kilowatthour (thousand watthours)
MWh = megawatthour (million watthours)

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